Surface Profile Analysis Reflectometer (SPEAR)

The Surface Profile Analysis Reflectometer (SPEAR) is used for determining chemical density profiles at solid or liquid interfaces. This instrument is used with an unpolarized neutron beam to study solid/solid, solid/liquid, solid/gas, and liquid/gas interfaces. SPEAR's moderated neutrons are coarsely collimated into a beam with an average angle of 0.9° to the horizontal that converges at the sample position, which is 8.73 m from the moderator. The neutrons can be further collimated to the desired divergence by finely slitting the beam. The largest vertical divergence is +/- 0.25°. In the horizontal direction, the beam converges at the detector with a maximum angular divergence of 0.45°.

A t-zero chopper, which interrupts the beam during the initial flash of high-energy neutrons and gamma rays, significantly reduces the background that may limit reflectivity measurements. A frame-overlap chopper, which defines the wavelength band to be used, suppresses frame-overlap background problems.

The sample stage allows solid samples to be accurately tilted in order to change the angle of incidence of the beam relative to the reflecting surface and permits sample-height scans for centering the samples in the beam. A vibration isolation system (Newport Corporation) supports the sample and actively dampens vibrations transmitted through the floor or air. SPEAR uses a single linear position-sensitive detector with 2-mm resolution for simultaneous studies of both specular and off-specular scattering.

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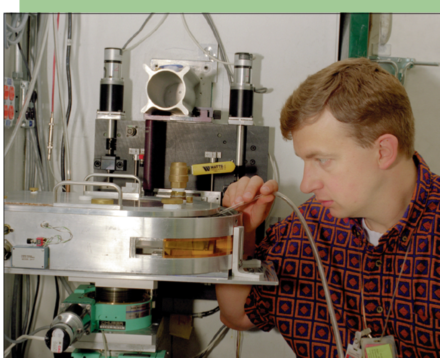

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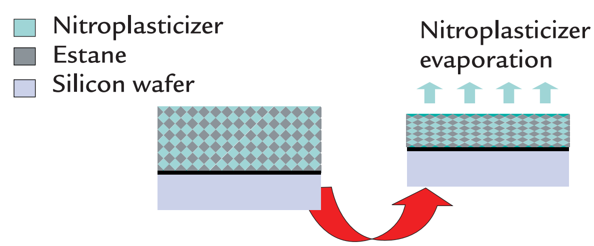
◄ Jarek Majewski cleans a liquid surface in preparation for deposition of a Langmuir monolayer.

SPEAR Specifications		
Moderator-to-detector distance	12.38 m	
Wavelength frames at 20 Hz	1 < λ < 16 Å and 16 < λ < 32 Å	
Q range (horizontal sample)	0.006 < Q < 0.20 $Å^{-1}$	
Beam cross section at sample position (maximum sample acceptance)	8 mm high x 30 mm wide	
Moderator	Partially coupled liquid hydrogen at 20 K	
Neutron flux at sample position at 100 μA	2 < λ < 6 Å 6 < λ < 16 Å	7.0×10^6 n/cm^2/s 1.5×10^6 n/cm^2/s
Detectors	Linear ^{3}He position-sensitive detector	
Minimum reflectivity	< 10^{-7}	
Sample environment	Solid/liquid interface cells; UHV evaporator; UHV oven; Langmuir trough; controllable humidity oven; and solid/liquid interface Poiseuille shear cell	
Experiment duration	1 minute to 6 hours	

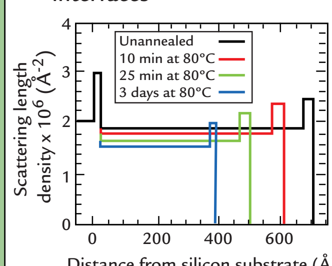
Understanding Loss of Plasticizer from Binder



Anneal at 80°C, the processing temperature for HMX

Neutron Reflection Reveals PBX 9501 Binder Aging Process

- Nitroplasticizer leaves the binder at a fast rate
- Diffusion of plasticizer within the binder is very rapid
- The surface evaporation of plasticizer is the rate-limiting step
- There are dense, thin polymer layers at the air and silicon interfaces



Binder
- Estane 5703™
- Nitroplasticizer
- Irganox 1010™ stabilizer